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(71) Applicant: GENERAL MOTORS CORPORATION
General Motors Building 3044 West Grand Boulevard
Detroit Michigan 48202(US)

(72) Inventor: D'Aniello, Michael Joseph Jr.
950 Francis
Rochester Michigan 48063(US)

(72) Inventor: Monroe, David Ross
1065 Timberlake Drive
Bloomfield Hills Michigan 48013(US)

(72) Inventor: Krueger, Martin Hans
27110 Collingwood
Roseville Michigan 48066(US)

(74) Representative: Haines, Arthur Donald et al,
GM Patent Section Luton Office (F6) P.O. Box No. 3
Kimpton Road
Luton, Beds. LU2 OSY(GB)

(54) **Regeneration of phosphorus-poisoned automotive catalysts.**

(57) Regeneration of a phosphorus-poisoned automotive exhaust catalyst is accomplished in a preferred embodiment by washing the catalyst or soaking it to the point of incipient wetness with an aqueous solution of a dibasic organic acid such as oxalic acid and subsequent heating of the wetted catalyst in air or other oxygen-containing gas.

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Croydon Printing Company Ltd

REGENERATION OF PHOSPHORUS-POISONED AUTOMOTIVE CATALYSTS

This invention relates to a method of restoring the activity of an automotive exhaust gas treatment catalyst that has been poisoned by phosphorus.

Background

Catalysts are employed on automobiles to treat engine exhaust gases to convert unburned hydrocarbons (HC) and carbon monoxide (CO) to carbon dioxide and water and to convert nitrogen oxides (NO_x) to nitrogen and water. Typically the catalysts comprise one or more noble metals such as platinum, palladium and rhodium in an extremely fine dispersion on a high surface area material such as gamma alumina. Such high surface area carrier may be in the form of an alumina pellet. In this case, the exhaust gas treatment is effected by retaining a bed of pellets in a suitable metal container which is shaped to direct the exhaust gas through the bed. In another arrangement, an extruded monolithic ceramic body is formed containing a large number of longitudinal open-ended passages. The body is of a refractory material such as cordierite. In this arrangement, the noble metal is dispersed on an alumina washcoat which in turn is carried by the cordierite body.

It is known that certain elements such as lead or phosphorus, if allowed to accumulate on the surface of the catalyst, will drastically reduce its ability (activity) to treat the exhaust gas as intended. For this reason, there are restrictions on the amount of lead or phosphorus that are added to engine fuels. However, phosphorus is still employed in lubricating oils. When oil is consumed in the ngine,

phosphorus can be deposited on the surface of the catalyst, inhibiting its activity. The exact chemical form of the deposited phosphorus may not be known. It is likely that the major phosphorus-containing poisons, in the absence of significant amounts of lead, consist of complex mixtures of metal phosphates and hydroxy-phosphates in varying degrees of hydration and crystallinity. These phosphorus-containing materials seem to glaze over the surface of the catalyst, preventing the noble metal from interacting with the exhaust gas.

A method of restoring the activity of an automotive exhaust gas treatment catalyst which has been poisoned, said catalyst containing one or more noble metals dispersed on a high surface area carrier, is disclosed in Japanese patent application No.118473/1977 (Daihatsu Kogyo Co., Ltd). The method involves the treatment of the poisoned catalyst with a mineral acid in order to dissolve and remove lead-containing catalyst poisons. Although mention is made in this Japanese patent application of the possibility of phosphorus compounds being adhered to the catalyst, the treatment of the poisoned catalyst with the mineral acid was not believed to effect removal of any such phosphorus compounds.

A method of restoring the activity of an automotive exhaust gas treatment catalyst containing one or more noble metals disposed on a high surface area carrier according to the present invention, where said catalyst has been poisoned by the presence of phosphorus on the surface of the catalyst, comprises the sequential steps of contacting the catalyst with an

aqueous solution of a dibasic organic acid, the amount of the solution being at least sufficient to wet and fill pores of the catalyst, and thereafter heating the acid-wet catalyst in air or in oxygen-containing automotive exhaust gas to remove water and acid from the catalyst.

Thus, in summary, a catalyst whose activity to oxidize hydrocarbons and carbon monoxide and to reduce NOx has been diminished because of phosphorus poisoning is treated with a solution of a suitable dibasic organic acid. The treatment may be in the form of one or more washes of the catalyst with a hot acid solution or it may be in the form of filling the pores of the catalyst with the solution to the point of incipient wetness. It is preferable to use an aqueous solution (about 1 molar in concentration) of oxalic acid or malonic acid or other suitable dibasic organic acid. The monolithic catalyst body or the catalyst pellets are thoroughly soaked with the acid solution. An abundance of hot solution may be employed to submerge and thoroughly wash the catalyst body. In this case, the hot wash dissolves the phosphorus-containing material. However, it is also suitable to use just that amount of acid solution required to just fill the pores of the catalyst material. This is termed the "incipient wetness treatment." Here the treatment with acid solution may be at normal room temperature or warmer. The acid solution remains in contact with the catalyst until equilibrium is reached. As a practical matter, the wetted catalyst is allowed to stand for about 30 minutes.

If the poisoned catalyst has been treated by washing with acid, the excess solution is drained from the catalyst. In either treatment the catalyst is then heated in flowing air or other oxygen-containing gas such as automotive exhaust gas to evaporate the solvent and drive off the acid. Suitably, in the heating, the catalyst reaches a temperature of about 500°C or so for a period of a couple of hours. Either treatment, by washing or by incipient wetness, surprisingly, rejuvenates the catalyst. Washing appears to remove the phosphorus or phosphorus-containing species. Acid treatment to incipient wetness redistributes the phosphorus so that it is not harmful to catalyst performance. So long as a suitable dibasic organic acid is used under suitable treatment conditions, neither treatment redistributes or adversely affects the catalyst particles on the beads or monolith.

Both aqueous mineral acid and aqueous solutions of dibasic organic acids are effective in exhaust catalyst rejuvenation. Treatment with inorganic mineral acids may be less expensive, but high temperature removal of the mineral acids can create a corrosive atmosphere which may be undesirable, depending on where the treatment is conducted. If the treatment is to be carried out in a garage or without removing the catalyst from its normal container, it is preferable to use a dibasic organic acid such as oxalic acid according to the method of the present invention. Heating of an oxalic acid-wetted catalyst in an oxygen-containing gas stream decomposes the acid into carbon dioxide and water, which are usually innocuous byproducts.

Other objects and advantages of the invention will be better appreciated from a detailed description thereof which follows.

Detailed Description

Samples of fresh pellet-type automotive exhaust treatment catalysts were obtained and tested to obtain base line data. The catalyst was that used on vehicles of General Motors manufacture and contained a dispersion of palladium and platinum on alumina beads. A 5 gram sample of the fresh catalyst was tested in a laboratory quartz tube reactor using a gas flow rate of 9 l/min (a space velocity of 50,000 h^{-1} at 1 atmosphere and 20°C). The reactor feed contained, by volume, 1% oxygen, 0.77% carbon monoxide, 0.2% hydrogen, 10% water, 10% carbon dioxide, 500 ppm nitrogen oxide, 300 ppm propylene, 20 ppm sulfur dioxide and the balance nitrogen. The reactor temperature was initially 200°C and was increased to 500°C at a rate of 5°C per minute. The degree of conversion of hydrocarbon (HC) and carbon monoxide (CO) of the fresh catalyst measured at 500°C under steady state conditions was 98.2% for hydrocarbon and substantially 100% for carbon monoxide. With no catalyst in the quartz tube, the HC and CO conversions were 8% and 5% respectively at 500°C. This blank conversion did not change in the course of the experiments, which will be described below.

A sample of the same type of catalyst which had been used in an operating vehicle over 36,900 miles was obtained. The catalyst sample was examined and observed to contain a significant amount of phosphorus. Its activity for conversion of HC and CO was measured in a laboratory tubular reactor as described above.

Its conversion efficiency at 500°C under steady state was only 55.0% for HC and 65.6% for CO. The reduction in conversion efficiency of the catalyst for both HC and CO seems to be a characteristic of phosphorus poisoning. In contrast, lead poisoning primarily affects HC conversion efficiency.

As outlined above, such a phosphorus-poisoned catalyst can be treated with acid solution in different ways. The catalyst may be totally immersed and washed in acid solution or it may be soaked with just sufficient acid solution to fill the pores of the catalyst with no visible solution left over -- i.e., to the point of incipient wetness. In washing, it is preferred that the catalyst pellets or monolithic body is submerged in a warm or nearly boiling aqueous solution of the acid. By washing in a suitable hot acid solution, it is usually possible to dissolve and remove most of the poisonous phosphorus-containing species from the catalyst body. However, in the incipient wetness technique, it is usually sufficient to treat initially with a solution at room temperature. In this approach the phosphorus is not removed from the catalyst body; it is redistributed on the body so that it does not interfere with the catalyst particles. Contact with the acid solution and/or heating of the acid solution-containing catalyst to remove the acid brings about the phosphorus redistribution before the acid is driven off the catalyst body.

In either treatment the catalyst is suitably allowed to remain in contact with the acid solution for 30 minutes, which is deemed sufficient for the acid and phosphorus-containing species to reach an equilibrium.

If the catalyst has been submerged and washed in hot acid, the extraneous solution is drained off and the wet catalyst is heated. If the catalyst has been treated to incipient wetness, it is permitted to stand and is then heated. In each case, the heating is carried out slowly so as to first evaporate the water and to drive off or decompose the acid. A typical practice was then to heat the body further to 500°C in air and to calcine it at that temperature for about two hours.

Samples of the above described phosphorus poisoned catalyst pellets were treated with various acids in aqueous solution at room temperature using the incipient wetness procedure. A ten gram sample of catalyst was treated with 6.5 ml of solution. The pellets were allowed to stand for 30 minutes and then loaded into a quartz tube furnace (as described above) at room temperature. Air flow was established and the furnace, preset at 500°C, was turned on. A thermocouple placed in the centre of the catalyst bed was used to follow the temperature of the sample. With this furnace and a 10g sample of wet oxalic acid-treated catalyst, the temperature rose to 100°C in 5 minutes and remained there for 11 minutes while water evaporated from the sample. The temperature then rose to 500°C over a period of 20 minutes and was held there for two hours. The HC and CO conversion efficiency was measured. The result of this testing is summarized below. The conversion efficiency of the fresh catalyst, untreated aged catalyst and mineral acid-treated catalysts are included for comparison.

TABLE I

Reagent	% Conversion Hydrocarbon	CO
non-fresh catalyst	98.2	100
non-aged catalyst	55.0	65.6
concentrated hydrochloric acid	93.3	93.5
concentrated nitric acid	91.8	93.5
concentrated hydrochloric/ nitric acids (3/1)	83.3	80.0
agueous oxalic acid (ca. 1 M)	95.3	97.4

It is seen that treatment of a phosphorus-poisoned catalyst with hydrochloric acid or nitric acid or with oxalic acid in accordance with the invention substantially increases the HC and CO conversion efficiency of the catalyst. In fact, most of the original activity was regained. Treatment with aqua regia (a mixture of concentrated hydrochloric and nitric acids) also increases the catalytic activity of the phosphorus-poisoned catalyst but to a lesser degree than the individual acids. Aqua regia is known to dissolve platinum and palladium and may have adversely affected the placement of these noble metals on the catalyst beads.

Improvements of similar or greater degree are also obtained by one or more washings of the catalyst with hot aqueous malonic or oxalic acid at about 65°C. Preferably the wash is carried out above ambient temperature but below the boiling point of the solution, e.g., 50° to 90°C. The respective catalyst samples were drained, dried, calcined and evaluated as described.

A number of aged General Motors pellet type oxidation catalysts, obtained from customers, were then analysed and rejuvenated. Table II summarizes the converter designation number; mileage; and phosphorus, lead, zinc, platinum and palladium contents of the respective catalyst samples. Table II also summarizes the HC and CO conversion efficiencies of the poisoned catalysts as received. These conversion efficiencies were determined in the above-described laboratory tubular reactor and synthetic exhaust gas was measured at steady state at 500°C. The listed data in Table II is the HC and CO conversion efficiencies of rejuvenated portions of the respective catalysts. Samples from each converter were treated by a single step incipient wetness treatment with 1M oxalic acid for 30 minutes followed by a two hour calcination at 500°C in flowing air.

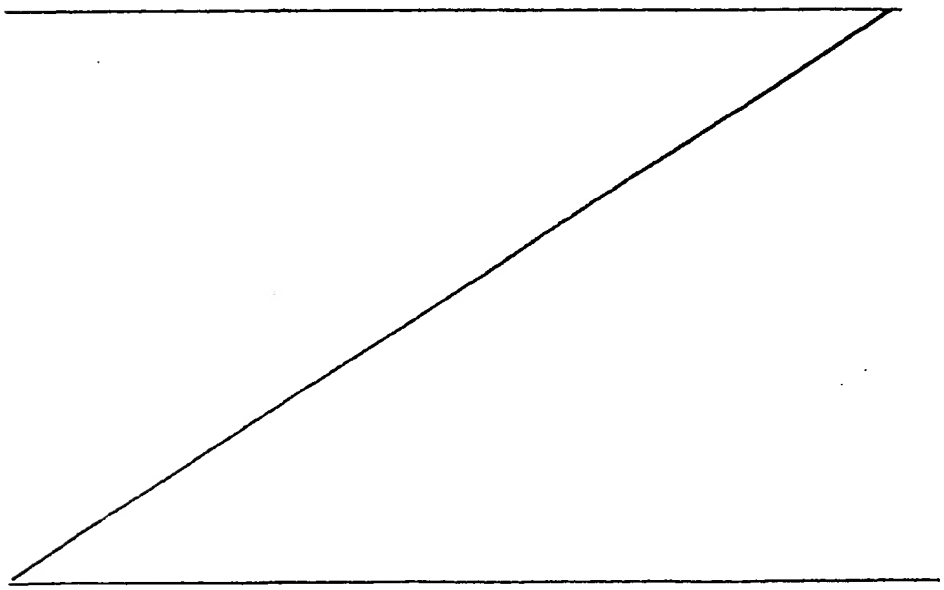

TABLE II

							As Received		Rejuvenated	
Converter	Mileage	%P	%Pb	%Zn	%Pt	%Pd	HC	CO	HC	CO
50143	38700	0.094	0.083	0.064	0.038	0.013	68%	75%	92%	95%
50144	33400	0.085	0.063	0.037	0.040	0.014	71%	78%	93%	97%
50145	36900	0.116	0.191	0.073	0.038	0.014	56%	64%	82%	89%
50147	24400	0.047	0.061	0.023	0.039	0.014	77%	84%	91%	95%
50149	57400	0.153	0.237	0.062	0.036	0.012	28%	36%	88%	92%
C-018	49700	0.071	0.271	0.047	0.036	0.012	52%	62%	79%	84%

It is seen that in each instance the present invention produces a marked improvement in the HC and CO conversion efficiencies of the catalyst as measured under the stated conditions. Furthermore, the HC and CO conversion efficiencies of the oxalic acid treated catalyst were greater than the respective efficiencies of the as-received catalysts at catalyst operating temperatures of 325°C and higher.

The rejuvenation technique was also tested on a full 4261 cc (260 cubic inch) converter load of catalyst pellets. The converter had been operated on an engine in a vehicle for 66,000 miles. As received, it displayed mild symptoms of phosphorus poisoning on actual engine tests at an air-fuel ratio of 15 to 1. With an exhaust temperature of 540°C, the HC conversion was 76% and CO was 98%. The pellets were then removed from the converter and treated to incipient wetness with 1M aqueous oxalic acid (about 2 litres required) in a bucket. The catalyst was treated outside of the converter to be sure that there was good distribution of the regeneration solution. The wetted catalyst was replaced in the converter and the vehicle installed on a dynamometer. The engine was started, allowed to idle for about 15 minutes and then run at 1800 rpm for one hour to stabilize the equipment before testing. During this operation, the catalyst was calcined by the oxygen-containing exhaust gas. The regenerated converter displayed an HC conversion efficiency of 89% and the CO conversion efficiency was 99%.

It has been found that organic acids, such as oxalic acid, adsorbed on the catalyst do not survive

the calcination step. They are decomposed to carbon dioxide and water, and this is desirable if catalyst regeneration is to be practiced in a garage or other place where calcination products are not readily trapped.

Scanning electron microprobe analyses of catalyst samples before and after regeneration by the present invention show marked differences in their phosphorus profiles. The as-received catalyst displays a sharp surface profile extending into the pellet some 40 μm while the regenerated catalyst has a much wider and lower profile extending to the centre of the pellet. This suggests that the redistribution of phosphorus away from the pellet edge improves catalyst performance, perhaps by opening blocked catalyst pores or by exposing noble metal which was covered up by the phosphorus-based poison.

Thus one is able to regenerate phosphorus-poisoned automotive exhaust catalysts by treatment with a solution of a suitable dibasic organic acid and subsequent removal of the solution by heating. The invention has been demonstrated with several types and concentrations of acids and treatment temperatures. Any suitable solvent can be used although water is preferred as the least expensive and easiest to handle. Preferably, a dibasic organic acid such as oxalic acid or malonic acid is used. Heating of these dibasic organic acids in an oxygen-containing environment decomposes them to carbon dioxide and water.

The present inventiuon provides a simple method of rejuvenating a phosphorus-poisoned automotive exhaust treatment catalyst. Additionally, the

invention provides a method of treating and rejuvenating a phosphorus-poisoned catalyst with a suitable acid solution that could be carried out by a mechanic in a garage without undue difficulty and without any need for environmental protection.

Claims:

1. A method of restoring the activity of an automotive exhaust gas treatment catalyst which has been poisoned, said catalyst containing one or more noble metals dispersed on a high surface area carrier, in which method the catalyst is treated with acid, characterised in that, where said catalyst has been poisoned by the presence of phosphorus on the surface of the catalyst, said method comprises the sequential steps of contacting the catalyst with an aqueous solution of a dibasic organic acid, the amount of the solution being at least sufficient to wet and fill pores of the catalyst, and thereafter heating the acid-wet catalyst in air or in oxygen-containing automotive exhaust gas to remove water and acid from the catalyst.

2. A method of restoring the activity of an automotive exhaust gas treatment catalyst according to claim 1, characterised in that the dibasic organic acid is either oxalic acid or malonic acid.

3. A method of restoring the activity of an automotive exhaust gas treatment catalyst according to claim 2, characterised in that the method includes the steps of washing the catalyst at least once in a hot, approximately one molar aqueous solution of oxalic acid or malonic acid, and then draining off the acid solution from the acid-wet catalyst.

4. A method of restoring the activity of an automotive exhaust gas treatment catalyst according to claim 2, characterised in that the method includes the step of soaking the catalyst with an approximately one molar aqueous solution of oxalic acid or malonic acid, the amount of the solution being just sufficient to wet and fill the pores of the catalyst.

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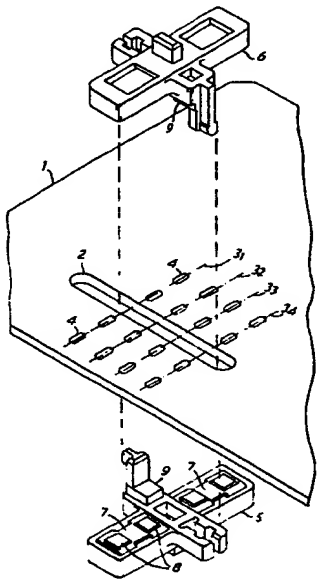
(71) Applicant: **THORN EMI Instruments Limited, Avocet House Archcliffe Road, Dover Kent, CT17 9EN (GB)**

(72) Inventor: **Gatland, Kenneth, 13, Channel Lea, Walmer Kent, CT14 7UG (GB)**

(74) Representative: **Marsh, Robin Geoffrey et al, Thorn EMI Patents Limited The Quadrangle Westmount Centre Uxbridge Road, Hayes Middlesex, UB4 0HB (GB)**

(54) **Switch contact assembly.**

(57) The invention provides a switch, which may be either a linear sliding switch or a rotary switch, having two complementary contact carriers (5, 6) disposed on opposite sides of a circuit board (1) having contact surfaces (4) connected to circuits on the board. The contact carriers engage each other through an aperture (2) in the board and contacts (7) resiliently mounted in the carriers oppose each other. They then bridge different contact surfaces (4) as the contact carriers are moved. The contact carriers may have at least some dummy contacts, especially if one side of the board has no circuits, but at least the resilient contacts, dummy or not, will oppose each other providing a fully floating contact arrangement in which forces acting as opposite sides of the board are substantially balanced. A beneficial and easily inserted form of a resilient contact 7 is disclosed.



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SWITCH CONTACT ASSEMBLY

The present invention relates to an electrical switch. It is particularly applicable to a switch, either a linear sliding switch or a rotary switch in which a sliding motion is about an axis, incorporated directly in a printed circuit board. In such an application the contact assembly is movable in a slot or aperture in the printed circuit board and contact members carried thereon are slid across the surface of the printed circuit board to bridge contacts in circuits formed on the board and thereby to select or modify the circuit layout in use.

Such a switch may have many different applications for circuits employing such circuit boards and may then be operated by a switch activator mechanism which can be mounted directly on the printed circuit board or on a mounting assembly or housing associated therewith.

A particularly beneficial form of switch activator mechanism for use with such a contact assembly is that disclosed in co-pending patent application No.81 21934. As disclosed in that application, the arrangement is particularly applicable to a digital multimeter in which such switches may be used to select different modes or ranges or as an on-off switch or for two or more of such purposes.

Electrical switches for use in association with printed circuit-boards have been proposed, for example in published British Patent Application 2050696A which shows a rotary switch in which a spring, biassing the contact carrier, serves also as a contact. A linear version is also envisaged therein. British Patents Nos.1506371 and 1252096 also show sliding

switches with spring contacts bridging conductors on a printed circuit board. It is believed, however, that these arrangements do not provide a sufficiently free movement in switching and that other alternatives similarly do not provide a satisfactory movement and moreover are generally not convenient, for example requiring special tools or equipment for assembly.

It is, therefore, an object of the invention to provide an improved switch and contact carrier for such a switch, which may be readily assembled without the use of special equipment.

According to one aspect of the invention there is provided an electrical switch including: a circuit board having an aperture formed therein and a plurality of contacts adjacent the aperture and connected to circuits on the board; at least one pair of complementary contact carriers disposed on opposite sides of the board; and at least one contact member mounted in one of said carriers and having contact surfaces adapted to contact and connect two or more of said contacts on the circuit board; wherein the complementary contact carriers of said pair are interengaged through said aperture to provide opposing and substantially balanced forces on the board and are jointly movable relative to the board to connect or disconnect two or more contacts.

According to another aspect of the invention there is provided a contact carrier including: at least one aperture; a contact member situated in the aperture with contact surfaces disposed externally thereof, the contact member being formed with openings therein and the apertures with projections at the side thereof to engage the openings; and a resilient member situated in the aperture, restrained by the contact member and biassing the contact member to retain said projections engaged with said openings.

The invention also embraces a method of assembling a contact carrier according to the preceding paragraph, the method including the steps of inserting the resilient member into the aperture, inserting the contact member into the aperture to pass under the projections against the resilience of the resilient

member and allowing the said resilience to urge the said openings into engagement with the projections.

In order that the invention may be clearly understood and readily be carried into effect it will now be described by way of example with reference to the accompanying drawings of which

Figure 1 shows a part of a circuit board with a sliding switch disassembled,

Figure 2 shows a similar switch to that of Figure 1 partly assembled,

Figure 3 shows a single contact carrier in accordance with the invention,

Figure 4a, 4b and 4c show plan, sectional side elevation and end elevation respectively of a contact for the carrier of Figure 3,

Figure 5a, 5b and 5c show plan, sectional side and end elevation respectively of an alternative form of contact,

Figure 6 shows the carrier of Figure 3 in perspective to illustrate the method of insertion of the contact,

Figure 7 is a plan view of a rotary switch contact carrier in accordance with the invention,

Figure 8 is an underplan view of the carrier of Figure 7,

Figure 9 is a section on A-A of Figure 7,

Figure 10 is a section on B-B of Figure 7,

Figure 11 is a section on C-C of Figure 7,

Figure 12 is an elevational view of the carrier of Figure 7,

Figure 13 shows two carriers as that of Figure 7 interlocked, the carriers being shown in the sectional views of Figure 11, and

Figure 14 shows in part the assembled contact carriers of Figure 13 with contacts in position therein.

In Figure 1 there is shown a part of a circuit board 1 which includes a sliding switch together with connections and other components which may take any suitable form and which have not been shown for the sake of clarity. For the purposes of the switch, the board 1 includes an aperture in the form of a slot 2 flanked by a plurality of rows 3 of contacts 4.

Contacts 4 are connected by conductors, not shown, to the circuits on board 2 in a pattern which is det rmined by the functions to be performed. In this example four rows of contacts 3_1 to 3_4 are provided and the sliding switch is intended to connect contacts in one row, bridging the two to one side of slot 2 and the two to the other side, and to be slid from one row to another. The circuit board 1 is also in this example a double sided circuit board carrying further connections and rows of contacts on the underside, not visible in Figure 1, so that each row of contacts comprises four pairs, the contacts of each pair being bridged for one row 3.

To achieve the bridging of the contacts the switch further includes two plastic contaet carriers 5 and 6 disposed on opposite sides of the board 1. Each contact carrier carries two conducting contacts 7 having raised contact surfaces in the form of pads 8, which in operation press against the contact 4 by virtue of suitable resilient means. Thus each contact 7 bridges two contacts 4 against which its pads 8 press at any time.

Each contact carrier also has a portion 9 which is complementary to slot 2 to slide within as can be better seen from Figure 2. That Figure shows a similar sliding switch on board 1 in which the lower carrier 5 has been fitted to the slot 2. Raised on part 9 is a male part in the form of a member 10 which fits a complementary female part formed as an aperture 11 on the other contact carrier. When fully assembled the carriers are on opposite sides of the board 1, both having their parts 9 within slot 2 and their members 10 and apertures 11 inter-engaged to hold the contact pads 8 against contacts 4 and to be slidably movable in slot 2 as indicated by arrows 12. To ensure a positive fitting and firm retention members 10 are formed with projections 13 and apertures 11 have slots 14 cut therein to be resilient.

Contact carriers 5 and 6 further include a projecting member 15 whose purpose is to engage an activator mechanism, such as that disclosed in the said Patent Application

No.8121934, by which the carriers are moved in slot 2. The contact carriers may of course be moved without the intermediary of an activator mechanism but that is not preferred.

As illustrated contact carriers 5 and 6 are identical, each carrying a portion 9, member 10 and aperture 11. This is advantageous since it reduces the number of parts required. It is not, however, necessary and one carrier may for example carry two members 10, the other having two complementary apertures 11. Furthermore if it is desired to use a single sided circuit board, a single carrier such as 5 may be mated with a dummy carrier or other suitable part entirely for the purpose of being retained thereby.

A contact carrier 5 is shown in cross-section in Figure 3 to show the fitting of the contacts 7. Similarly suitable contacts are shown in plan, sectional side elevation and end elevation in Figures 4a, 4b and 4c respectively and in another form in Figures 5a, 5b and 5c respectively.

The contacts 7, which are formed of copper with a precious metal contact face, have the two contact pads referred to hereinbefore and two sidewalls 16 and on the bends between the top surface and each sidewall 16 have an opening or cut-out 17 between the two pads 8.

The contact carriers 5 and 6 are formed with apertures 18 in which the contacts 7 may be inserted. They are also formed with projections 19 facing inwardly of the apertures 18 to engage cut-outs 17 on the contact 7 and thereby retain the contacts. The contacts are placed in apertures 18 with contact pads 8 facing outwards and a resilient metal member 20 is placed within aperture 18 to urge contacts 7 outwardly. This serves partly to retain the contact, pressing the sidewall edges of cut-outs 17 against projections 19 and also serves to provide the resilience referred to hereinbefore to maintain pads 8 in firm contact with contact 4 on the circuit board.

This form of construction allows the assembly to be readily assembled without the use of special tools as can be seen in the perspective view of Figure 5 in which one contact 7 is partly

inserted.

The first step in assembly is to insert the resilient member 20 into the aperture 18, as is shown to the right hand side in Figure 5. Subsequently the contact 7 is inserted in the direction shown by the arrow 21 on the left hand side in Figure 5. It is pressed against the resilience of member 20 under the projections 19 and when in place allowed to rise with the projections 19 engaged in cut-out 17. Member 20 is shaped to facilitate this insertion but clearly need not be exactly as illustrated.

It will be apparent that the insertion of member 20 and contact 7 comprises two simple actions and yet provides positive positioning and resilience of contact. Furthermore the subsequent positioning of carriers 5 and 6 on opposite sides of board 1, as shown in Figure 1 with parts 9 in slot 2 and members 10 and apertures 11 inter-engaged is also a simple and yet positive procedure.

The provision of opposed contacts on opposite side of the circuit board, each resiliently mounted, contributes to the advantageous fully floating nature of the contact assembly. In this arrangement all of the forces tend to oppose each other and there is substantially equal pressure on each pair of contacts.It should appreciated, however, that it is not necessary for these all to be fully operational contacts to achieve this effect. Any of the aperatures 18 may include a dummy contact, perhaps of insulating material. Conveniently the active contacts may be on one side of the circuit board with all contacts on the other side being dummy ones.

Furthermore although it is preferred that the two contact carriers are identical, it is not necessary that they should be so provided they are complementary to the extent of being interlocking and providing opposing contacts when interlocked. Other interlocking arrangements than those illustrated may be used.

In the preferred example the contact carriers are moulded of 10% glass filled polycarbonate although many other materials

may be used.

The embodiment particularly described hereinbefore is for a switch in which the sliding motion is a linear one so that a linear switch is obtained. The invention, however, is suitable for application to switches using other motions of which a rotary motion is particularly convenient. In that case the aperature through which the complementary contact carriers interengage is generally circular.

In Figure 7 there is shown a rotary contact carrier 1 in plan and in Figure 8 the same contact carrier in underplan. These Figures should be viewed with Figures 9, 10 and 11 which show respectively sections on A-A, B-B and C-C of Figure 7. Figure 12 also shows a side elevation of the carrier.

The carriers include apertures 18 which correspond to the similarly numbered apertures in the carriers described hereinbefore.

By means of similar projections 19 and resilient members (which are not shown in Figures 7 - 13 but which may be the same as those identified by reference numeral 20 in Figures 3 and 6) there are mounted in a resilient manner contacts which may be the contacts 7 shown in Figure 4 or Figure 5. The contact carrier in this example has four arms 21 disposed symmetrically about a hub part 22, each arm having a respective aperture 18.

Different numbers of arms 21 may be provided according to the purpose required. Two or more arms, evenly spaced would achieve the balance required although too many arms may become unwieldy so that four is a preferred number.

The hub part 22 has a central concavity 23 in the upperside with an aperture 24 axially therein. To one side is a projection 25 and the concavity has a rim 26 extending over slightly greater than 270° leaving a part 27 of less than 90° having no rim 26.

For assembly, two identical contact carriers are disposed on opposite sides of a circuit board having an aperture sufficient to accommodate the locking parts 25 and 26. The contact carriers are axially aligned and offered to the aperture

at relative rotational positions so that the projections 25 of each, approach the part of the other at which there is th gap 27 in rim 26. When each projection 25 is suffici ntly introduced the two contact carriers are rotated relative to the other so that each part 25 is engaged under the rim 26 of the other. The rotation is continued until the projections 25 are on opposite sides of the axis and the arms 21 of each are aligned on opposite sides of the circuit board.

For a better illustration of the locking arrangement Figure 13 shows two contact carriers, each in the section view of Figure 11, fully engaged on opposite sides of a circuit board 27. The circuit board has an aperture 28 through which the interlocking parts 25 and 26 engage.

The arrangement allows of firm, but not permanent, interlocking of the two parts so that the two carriers may be rotated about their common axis 29 to effect the switching action.

Figure 14 shows in part an assembled pair of contact carriers as in Figure 13 but with the contacts 7 in position as in the fully assembled switch.

CLAIMS

1. An electrical switch including: a circuit board having an aperture formed therein and a plurality of contacts adjacent the aperture and connected to circuits on the board; at least one pair of complementary contact carriers disposed on opposite sides of the board; and at least one contact member mounted in one of said carriers and having contact surfaces adapted to contact and connect two or more of said contacts on the circuit board; wherein the complementary contact carriers of said pair are interengaged through said aperture to provide opposing and substantially balanced forces on the board and are jointly movable relative to the board to connect or disconnect two or more contacts.

2. A switch according to Claim 1 in which said aperture is a slot and the pair of contact carriers are mated therewith to be capable of a linear sliding action on the board to connect or disconnect said contact.

3. A switch according to Claim 1 in which said aperture is generally circular and the pair of contact carriers are mated therewith to be capable of a rotary action on the board to connect or disconnect said contacts.

4. A switch according to Claim 3 in which each contact comprises a hub part adapted to engage the other contact carrier through said aperture and a plurality of arms, at least some of which carry at least one contact member, radiating from the hub so that, when the contact carriers are interengaged, contact carrying arms of one contact carrier oppose contact carrying arms of the other contact carrier.

5. A switch according to any preceding claim in which the circuit board has contacts on both sides and both of the pair of complementary contact carriers have at least one contact member adapted to contact and connect two or more of said contacts on a respective side of the board.

6. A switch according to any of claims 1 to 4 in which one of said pair of complementary contact carriers has at least one dummy contact member adapted to substantially balance forces on the circuit board from an opposing contact member of the other carrier without itself connecting contacts.

7. A switch according to any prec ding claim in which each contact carrier includes means engaging the at least one contact member and resilient means urging the contact member against the means for engaging.

8. A contact carrier including: at least one aperture; a contact member situated in the aperture with contact surfaces disposed externally thereof, the contact member being formed with openings therein and the apertures with projections at the side thereof to engage the openings; and a resilient member situated in the aperture, restrained by the contact member and biassing the contact member to retain said projections engaged with said openings.

9. A contact carrier according to Claim 14 having complementary male and female members to engage complementary members on a similar contact carrier.

10. A method of assembling a contact carrier according to either of claims 14 and 15, the method including the steps of inserting the resilient member into the aperture, inserting the contact member into the aperture to pass under the projections against the resilience of the resilient member and allowing the said resilience to urge the said openings into engagement with the projections.

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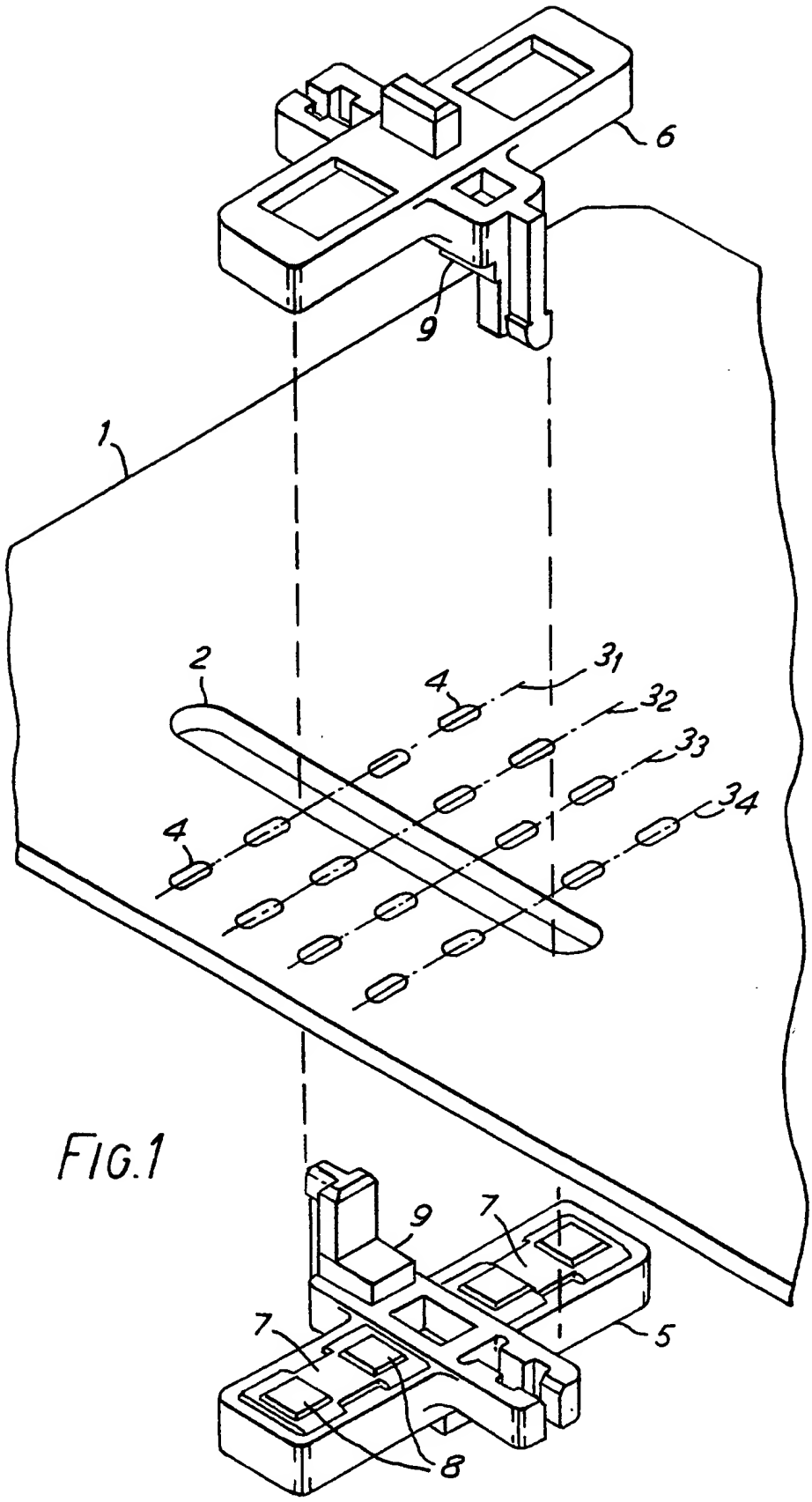

FIG.1

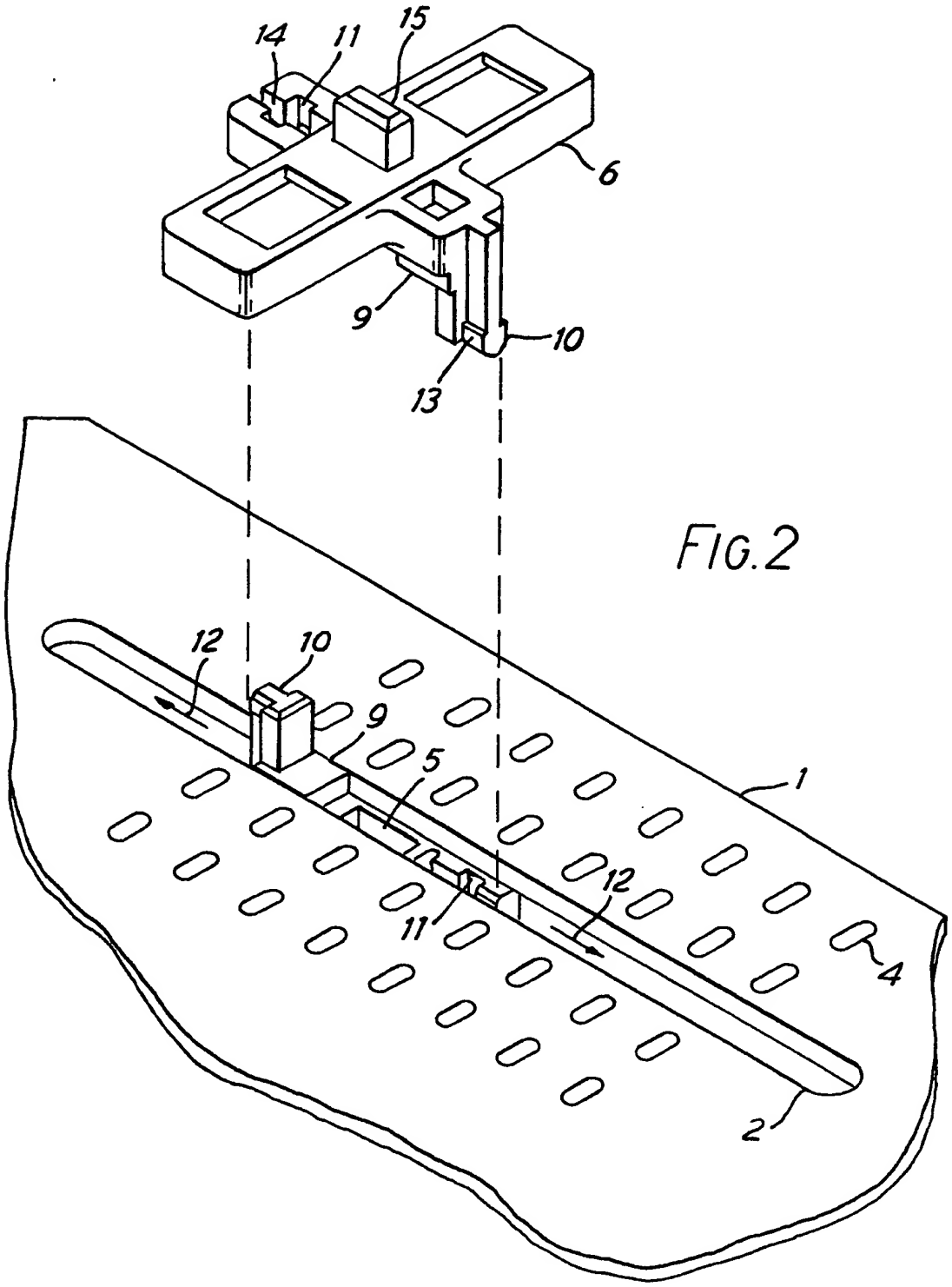

FIG.2

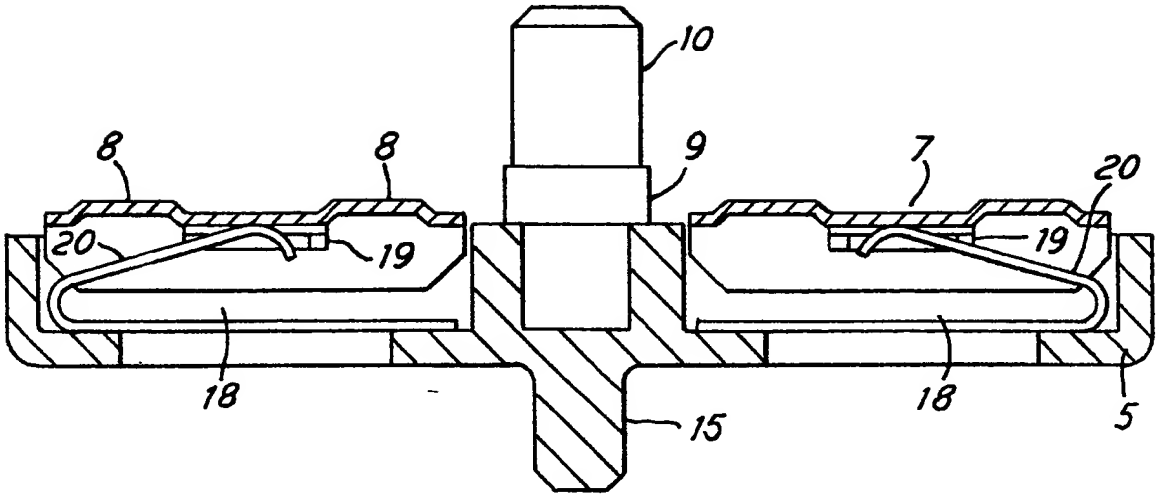

FIG. 3

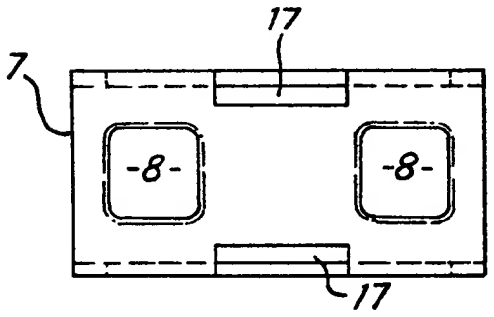

FIG. 4a

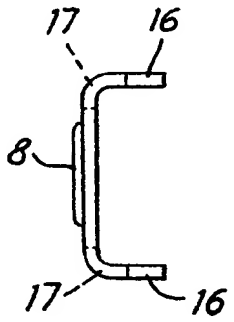

FIG. 4c

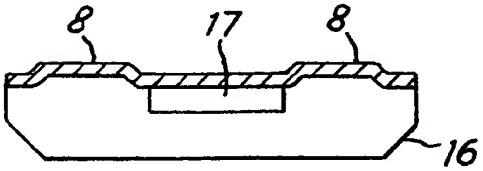

FIG. 4b

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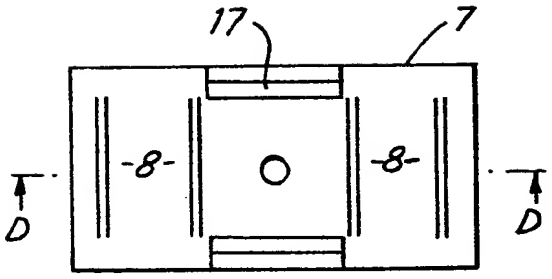

FIG. 5a

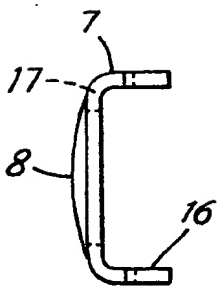

FIG. 5c

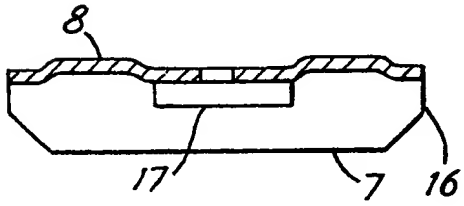

FIG. 5b

5/

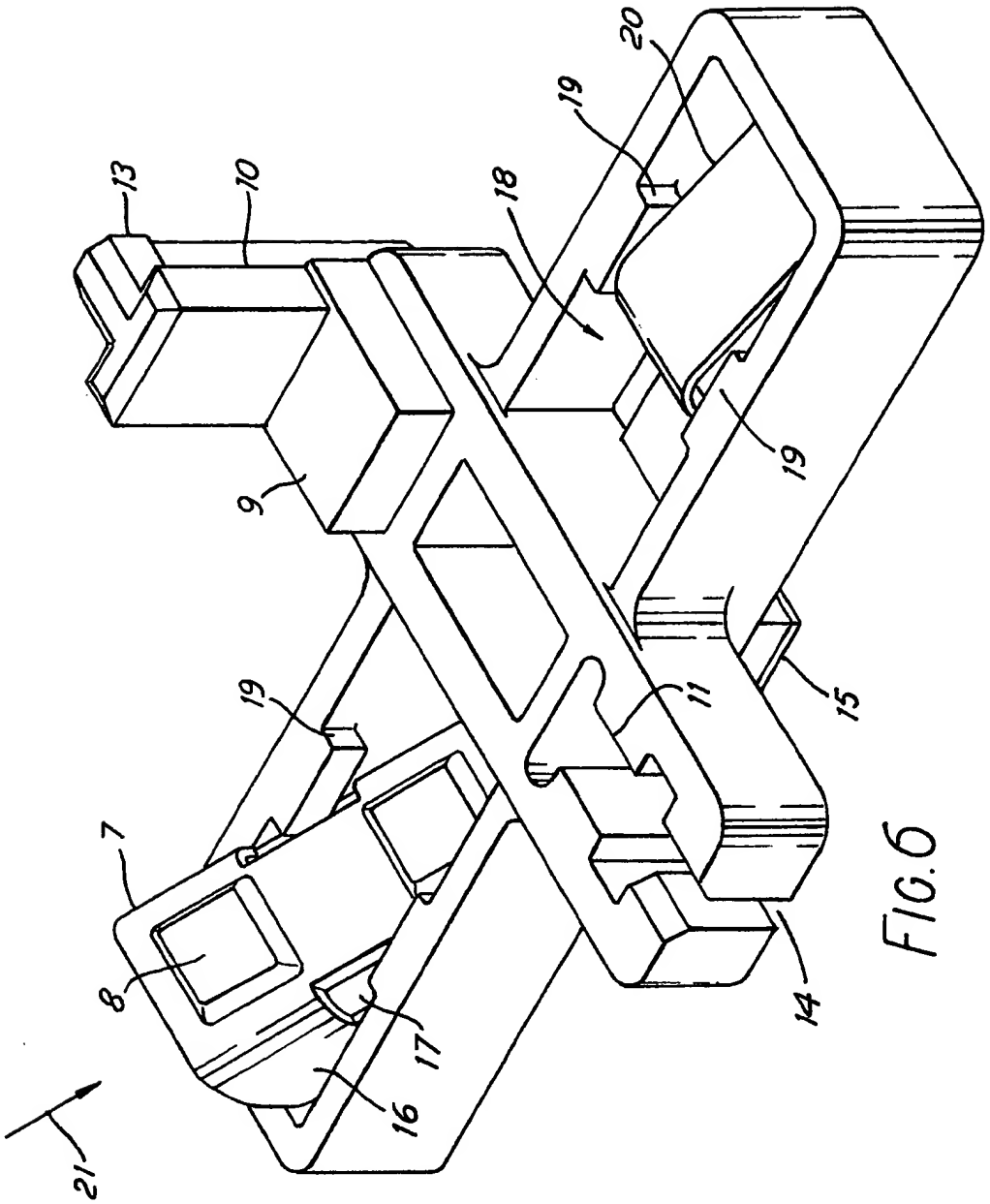

FIG.6

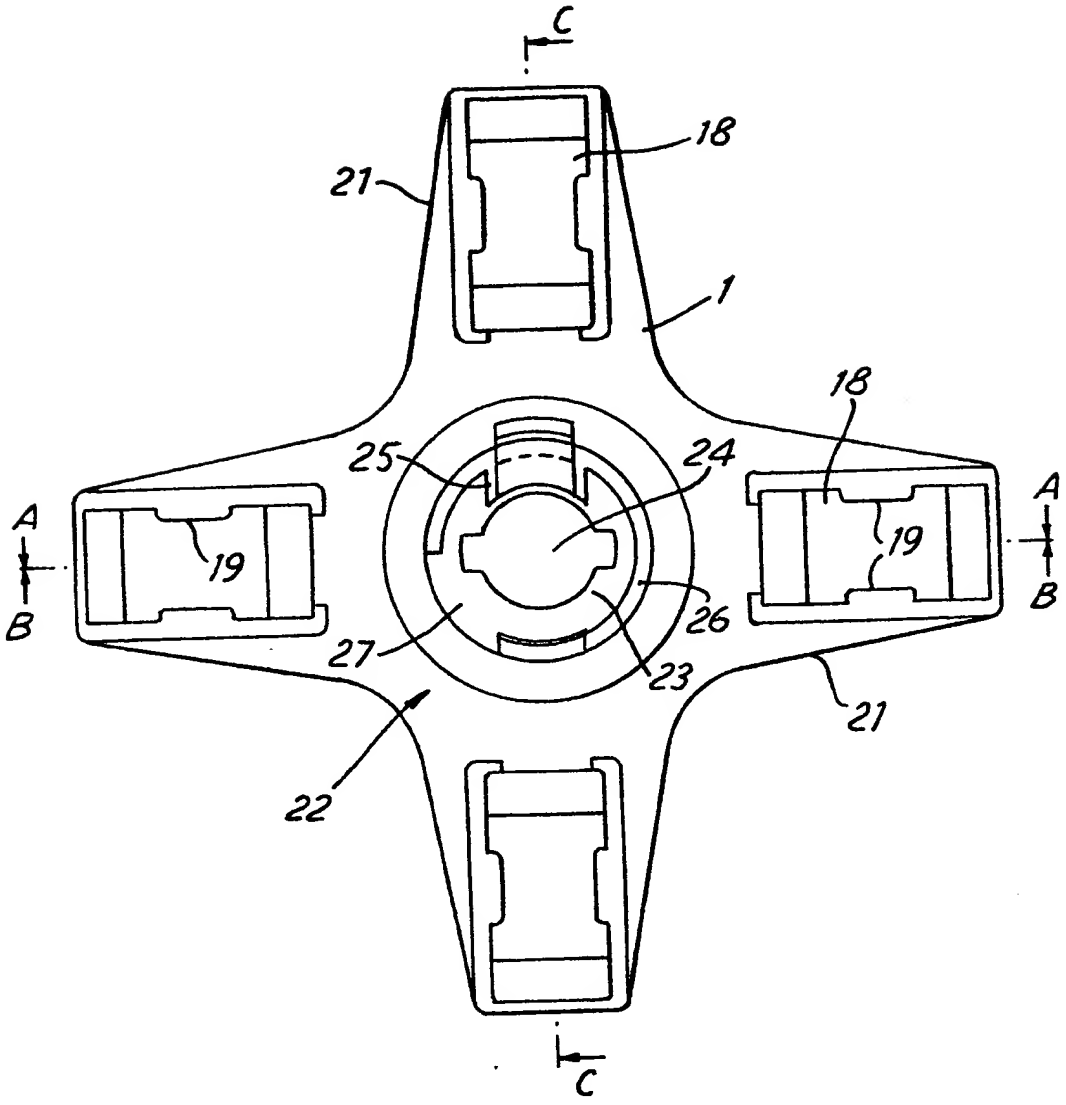

FIG.7

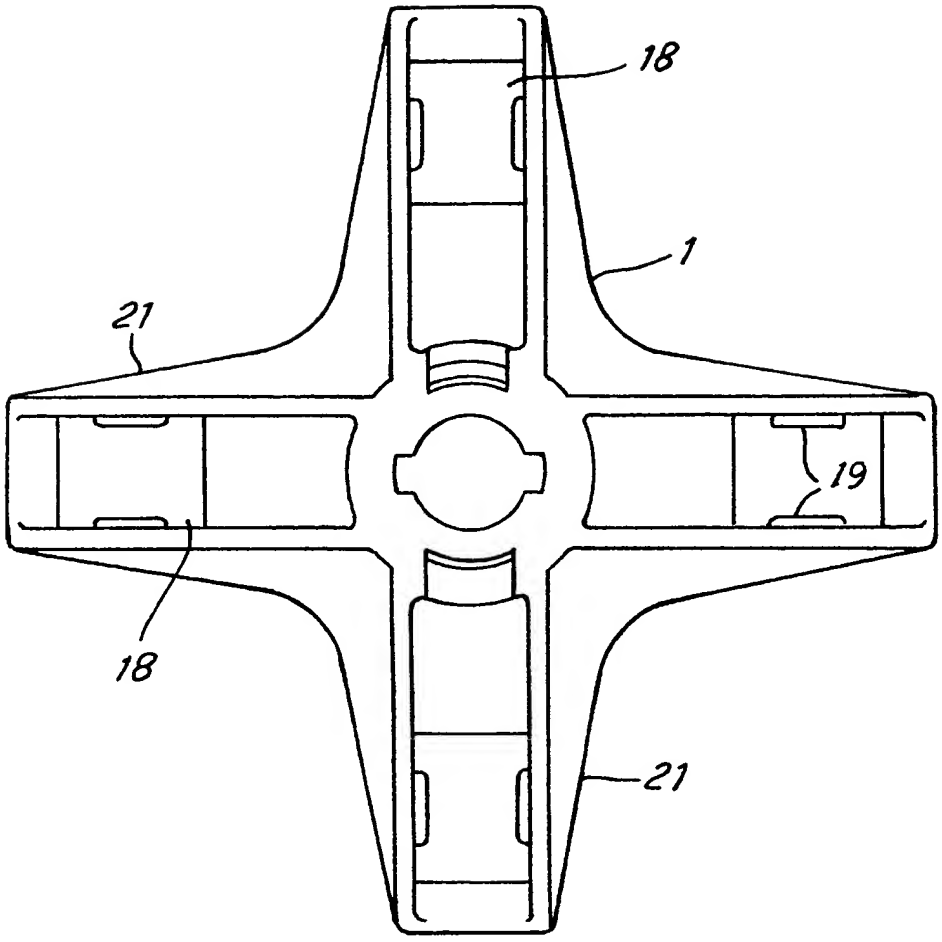

FIG.8

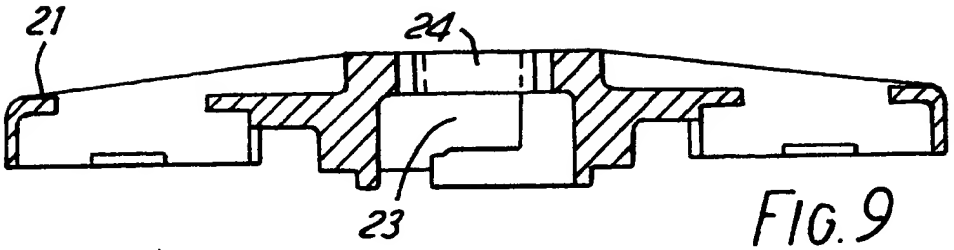

FIG. 9

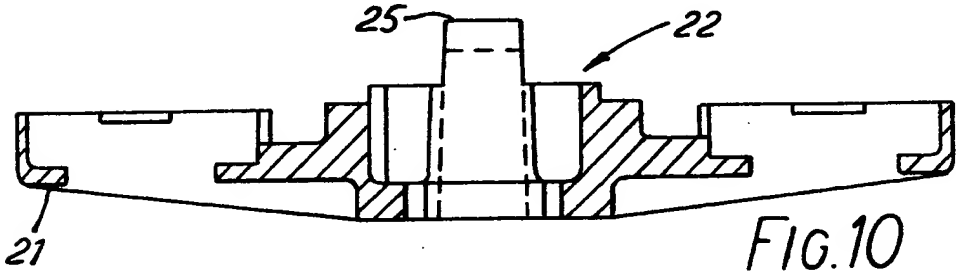

FIG. 10

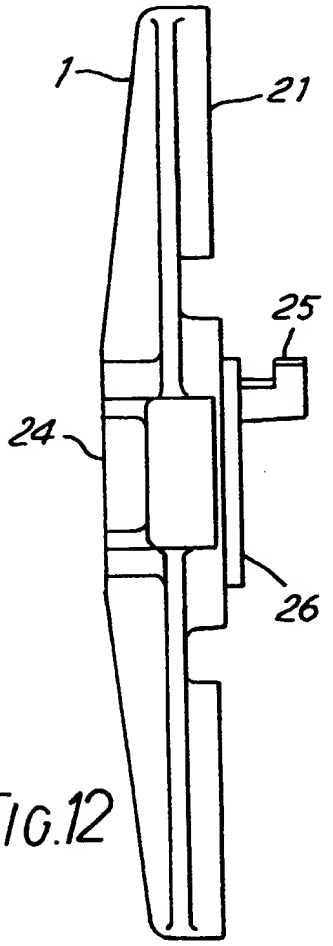

FIG. 12

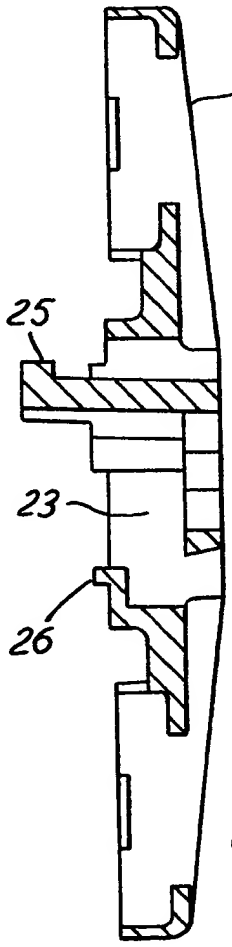

FIG. 11

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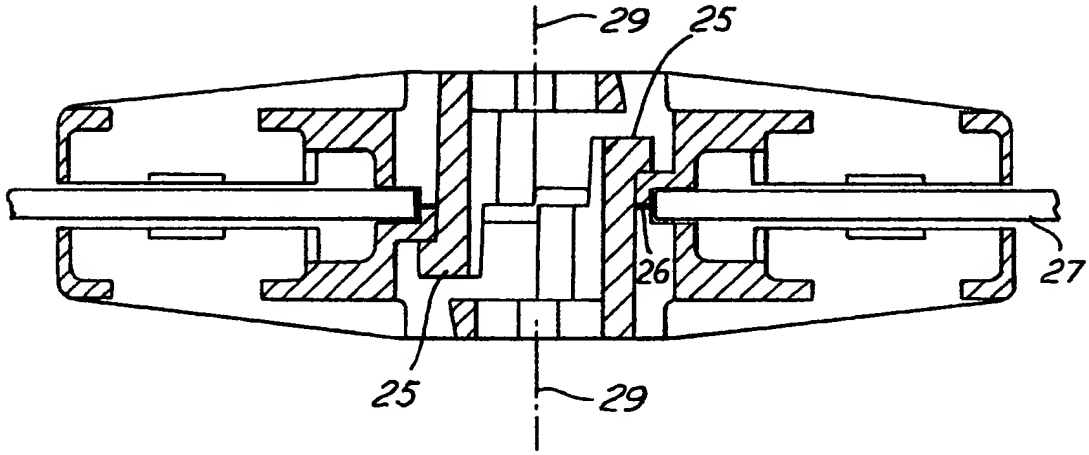

FIG.13

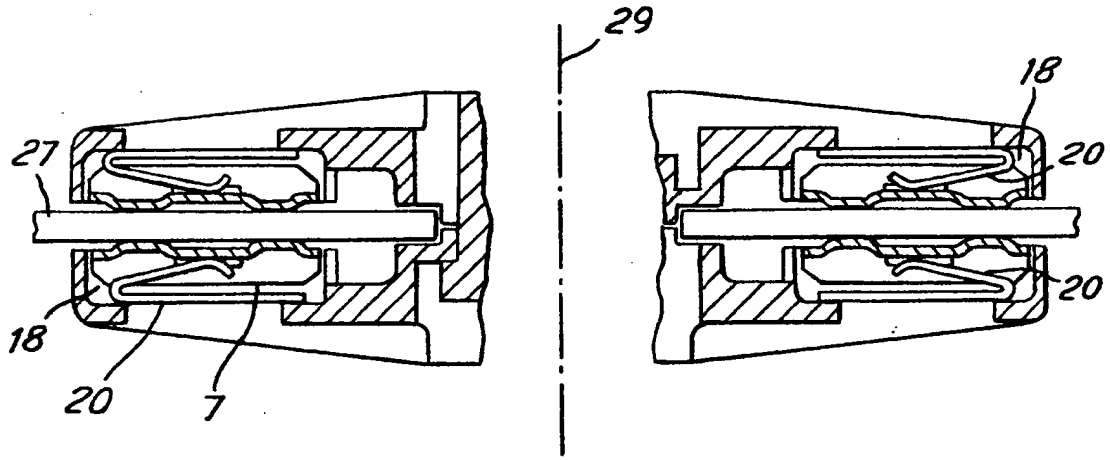

FIG.14

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